COPY NO. 10

TECHNICAL REPORT 4783

S-TRINITROBENZENE AS A BINDER IN COMPRESSION-MOLDED EXPLOSIVE COMPOSITIONS

FRANKLIN B. WELLS

NOVEMBER 1975

PICATINNY ARSENAL
DOVER, NEW JERSEY

The findings in this report are not to be construed as an official Department of the Army Position.

DISPOSITION

Destroy this report when no longer needed. Do not return to the originator.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Date Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report 4783	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) S-TRINITROBENZENE AS A BINDER IN COMPRESSION-MOLDED EXPLOSIVE COMPOSITIONS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Franklin B. Wells		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Explosives Div, Feltman Research Laboratory Picatinny Arsenal Dover, N.J. 07801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE NOVEMBER 1975 13. NUMBER OF PAGES 16
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

S-Trinitrobenzene	RDX binder	HMX
HMX binder	Polytetrafluoroethylene (Teflon)	TNT
Molding powder	TNT replacement	
Compression molding	RDX	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Cycletetramethylenetetranitramine HMX s-trinitrobenzene (TNB) ratios and loading parameters required to provide compression-molded HMX/TNB articles that approach the theoretical maximum density (TMD) were established.

It was also shown that the HMX used need not be very fine-grained.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Date Entered)

The citation in this report of the names of commercial firms or commercially available products or services does not constitute official endorsement or approval of such commercial firms, products, or services by the US Government.

TABLE OF CONTENTS

INTRODUCTION

The relatively low melting point of trinitrotoluene (TNT) and its tendency to exude have long been recognized as factors limiting its utility in very hot environments. Trinitrobenzene has a relatively high melting point and offers promise as a replacement for TNT in high temperature applications.

Selection of TNB for investigation as a replacement for TNT as a fusible explosive matrix was based on the following tabulated data (the ballistic pendulum value of TNB was determined in this laboratory):

Comparison of TNT and TNB

	TNT	TNB
Melting point (°C)	81°	123°
Crystal density (g/cc)	1.654	1.6757[a]
Unconfined detonation velocity (m/sec):		
cast (density = 1.64 g/cc)	6640	-
pressed (density = 1.64 g/cc)	6825	7000
pressed (density = 1.66 g/cc)	-	7350
pressed (density = 1.68 g/cc)[b]	-	7440
Ballistic pendulum value	1.000	1.125

The above data shows that TNB melts at a much higher temperature than TNT and that it is both more powerful and brisant than TNT. In addition, the advantages of improved heat resistance inherent in the replacement of TNT with TNB can be expected to essentially eliminate exudation under normal conditions of storage and use.

---

[a] Choi and Abel (Ref 1) have studied the crystal structure of TNB in detail and with the aid of Buerger (Ref 2). Abel (Ref 3) has calculated its crystal density to be 1.6757 g/cc, the value used in this report.

[b] Value shown obviously is in error since it is above crystal density.

During the consideration of the above-noted possibilities, it became obvious that the use of TNB as a binder for injection- and/or compression-molded charges for various ordnance items, particularly exterior aircraft ordnance, should be investigated. Compression-molding was undertaken as a first step in the study of the use of TNB as a binder.

MATERIALS

TNB

About five pounds of TNB was obtained from the Eastman Kodak Co. in 100 g bottles bearing the nomenclature, "TNB Eastman Kodak Co. Catalog No. 639, m.p. 121-122°." This material was subjected to the following tests:

1. Melting point (°C)[a]

Test No. 1	123-124.5° (124.5°)[b]
Test No. 2	123-124.5° (124.5°)[b]

2. Ballistic pendulum test (TNT=1)[c]

Average value	1.125

TNT

Type I TNT, as defined in Reference 6, and designated as "Lot No. KNK 11-270, Type I, Flake, SMUPA 1B8494, Re-blended," was obtained for use in this work.

---

[a]Determined with an Arthur H. Thomas Co's. "uni-melt" Hoover Capillary Melting Point Apparatus using only material that passes a USS (United States sieve size) no. 40 and a heating rate of 0.5-1.0°C per minute.

[b]The figures in parentheses were obtained by removing the capillary melting point tubes from the bath as seen as the melting point had been determined, allowing these to cool for at least 15 minutes, and repeating the melting point operation on the solidified material. In this case only the temperature at which complete melting occurred was noted.

[c]Reference 5.

Polytetrafluoroethylene (PTFE)

A one-quart sample of this material, an aqueous dispersion, was obtained from E. I. DuPont de Nemours & Co. bearing the label "VM-261 PTFE CLEAR." When evaporated under vacuum to constant weight it was found to contain 62.68% solids (as C_2F_4).

RDX

Essentially anhydrous Type B, Class E RDX, as defined in Reference 4 bearing the designation "Lot No. HOL-SR-545-62" was used in this work. The characterization results obtained follow:

1. Vacuum stability (as gas evolved in ml/5g/40 hrs)[a]

at 140°C	0.81
at 150°C	4.32

2. Hygroscopicity (%)[b] 0.01

3. Melting point (°C)[c] 197.3

4. Fisher sub-sieve value (microns) 12.5

5. Electrostatic sensitivity test (joule)[d] 1.3

6. Granulation (%)[e]

Standard USS	on (%)	through (%)
100	0.00	100.00
200	0.70	99.30
325	1.50	97.80

---

[a] References 7 and 8.

[b] A preweighed dry sample is held 48 hours in a 90% relative humidity atmosphere at 30°C and the result reported as percent gain in weight of the sample.

[c] Determined with an Arthur H. Thomas Co's. Hoover Capillary Melting Point Apparatus ("uni-melt") using only material that passes a USS no. 40 and a heating rate of 0.5-1.0°C per minute.

[d] Reference 8.

[e] Table II, Reference 4.

HMX

Two different classes of essentially anhydrous HMX, as defined in Reference 9, were utilized in this project:

1. HMX, Grade II, Class B, Lot No. HOL-SR-655-61, Batch BF 385

2. HMX, Grade II, Class C, Lot No. HOL-SR-41-63

The characterization test results are:

	HMX 655-61	HMX 41-63
1. Melting point (°C)[a]		276.2
2. Granulation (% on USS)[b]		
USS no.		
12	0.00	0.00
30	0.00	0.00
35	0.00	9.51
50	0.00	37.24
60	0.00	10.12
80	0.00	11.86
100	0.00	8.00
200	2.25	10.38
230	0.15	1.13
325	2.53	2.19
Pan	94.97	1.45

[a] Determined with an Arthur H. Thomas Co's. "uni-melt" Hoover Capillary Melting Point Apparatus using only material that passes a USS no. 40 and a heating rate of 0.5-1.0°C per minute.

[b] Expanded version of Table 1, Reference 9.

EXPERIMENTAL PROCEDURE

Establishing the optimum conditions for preparing high density TNB-bonded compression-molded articles and fills of various compositions was accomplished in the following manner. Twenty-gram pellets were formed in an oil-heated press with a 3/4 inch diameter die at various temperatures and pressures using material which passed through a no. 20 USS. In the early part of the work only the temperature inside the mold (noted as "Air temp" in the tabulated data) at the time of loading was recorded. Later, the temperature of the circulating heating oil was also recorded. For pressing, the air temperature inside the covered mold was raised to the desired point, the unheated material was placed in the mold, the ram, also heated, inserted without applying pressure on the contents, the air evacuated to reduce internal pressure to 3-4 mm Hg for five minutes, the ram pressure applied for a five minute dwell period, and the pellet removed to cool in a covered container placed in a draft-free location. It is to be noted that results obtained under the conditions described are characteristic of the press used and can not be translated directly to presses of other sizes, shapes, or modes of operation.

PTFE-containing Compositions

The use of PTFE, widely known as Teflon, as an internal lubricant to aid compression-molding was briefly considered. Reference 10, which deals with the addition of PTFE as an aqueous dispersion to molten TNT to improve various characteristics, served as the basis of this consideration.

Accordingly, and essentially as described in Reference 10, PTFE was added to stirred molten TNT held on the hot water bath. The addition was accomplished over a five minute period. Composition 1 was stirred 10 minutes after PTFE addition was completed, the stirring stopped, and the vessel removed from the heat and allowed to stand on the bench to cool. It first set to a jelly and then hardened. Composition 2 was similarly prepared but instead of removal from the bath, the heat was turned off and the mixture stirred as it cooled until solidification. The following day, both materials were broken up and passed through a no. 20 USS to provide molding materials of a somewhat fibrous consistency.

The first step in the preparation of composition 3, and all following compositions, was the addition over 1-2 minutes of a 1/5 TNB/acetone solution to hand-stirred HMX or RDX followed by stirring under a gentle air stream until the mixture appeared to be dry and then allowed to set open to the air overnight. After breaking and sieving the mixture, the

particles were thoroughly wet with 20 ml distilled water and 5 grams PTFE suspension stirred in. The mixture was allowed to stand open to the air overnight and this material then vacuum dried for 24 hours. The dried material broke up readily to produce somewhat fibrous particles which, on being pressed together with a spatula, formed a very porous weak sheet.

Additive-free TNB/HMX or RDX Compositions

Compositions 4 through 10 were prepared as in the first step of composition 3 and compression-molded under varying conditions to establish optimum TNB/HMX or RDX ratios. As part of this work, coarse HMX was also used.

COMPOSITIONS

PTFE-containing Compositions

Composition no.	1	2	3
TNT (g)	145.0	145.0	-
TNB (g)	-	-	5.000
HMX 655-61 (g)	-	-	92.000
PTFE (g dry wt)	7.584	7.584	3.134
TMD (g/cc)	1.674	1.674	1.896

Additive-free TNB/HMX or RDX Compositions

Composition no.	4	5A	5B	6	7	8	9	10
TNB (g)	8.0	5.0	5.0	5.0	5.0	4.0	3.0	2.0
HMX 655-61 (g)	92.0	95.0	95.0	50.0	-	96.0	97.0	98.0
HMX 41-63 (g)	-	-	-	45.0	-	-	-	-
RDX (g)	-	-	-	-	95.0	-	-	-
TMD (g/cc)	1.880	1.887	1.887	1.887	1.803	1.890	1.892	1.894

RESULTS

Compression-molding at 5,000 psi

Composition no.	1	2	3	4
Air temp (°C)	70°	70°	120°	120°
Pellet density (g/cc)	1.638	1.616	1.874	1.877
% TMD	97.28	95.98	98.87	99.84

Composition no.	5B	6	7
Air temp (°C)	109-100°	109-110°	109-110°
Oil temp (°C)	156-160°	156-160°	156-160°
Pellet density (gm/cc)	1.845	1.823	1.766
% TMD	97.75	96.59	95.17

Compression-molding at 10,000 psi

Composition no.	1	2	3	4
Air temp(°C)	70°	70°	120°	120°
Pellet density (g/cc)	1.649	1.635	1.880	1.881
% TMD	98.52	97.68	99.88	100.05[a]

[a]The greater than 100% TMD value obtained here is thought to be due to loss of TNB which was squeezed out during pressing. It was estimated, on the basis of results obtained with composition no. 3 and compositions containing a 95/5 HMX/TNB mixture, that at least three parts of TNB were lost in pressing. The 98/2 HMX/TNB mixture left would then have a TMD of 1.887 g/cc and the pressed density of 1.881 g/cc obtained would be 99.67% of this TMD.

Composition no.	5A	5B	6	6	7
Air temp (°C)	110°	109-110°	109-110°	120°	109-110°
Oil temp (°C)	160°	154-160°	156-160°	160°	156-160°
Pellet density (g/cc)	1.884	1.864	1.868	1.878	1.779
% TMD	99.79	98.75	98.98	99.51	97.95
Composition no.	7	8	8	9	10
Air temp (°C)	120°	114°	110°	120°	120°
Oil temp (°C)	160°	150°	148-149°	160°	160°
Pellet density (g/cc)	1.786	1.882	1.879	1.88[a]	1.87[a]
% TMD	98.66	99.56	99.44	99.20	98.46

Compression-molding at 15,000 psi

Composition no.	5A	6	7	8
Air temp (°C)	110°	120°	120°	110°
Oil temp (°C)	160°	160°	160°	148-149°
Pellet density (g/cc)	1.883	1.878	1.797	1.882
% TMD	99.77	99.50	99.67	99.58

[a]These figures are not of the same degree of accuracy as those obtained with pellets of other compositions. During determination of the weight of the pellets in water, air bubbles formed on the pellets. In the case of composition no. 9 the bubbles remained small and did not leave the pellet surface. In the case of composition 10 the bubbles became large enough so that several broke away from the pellet and rose to the surface of the water. Such results make it obvious that 3% or less of TNB is not sufficient to fill the interstices between HMX particles and therefore is less than optimum.

DISCUSSION AND CONCLUSIONS

Loss of an appreciable amount of TNB during compression-molding of composition 4 has been previously discussed. In this connection, it is to be noted that, in general, 95/5 HMX/TNB compositions showed a slight TNB loss when compressed at 10,000 and 15,000 psi but not at 5000 psi. The loss could be detected as a shiny film on the hot ram face. When cool, the film was difficult to detect. Use of finer HMX probably would eliminate this loss as the 95/5 RDX/TNB composition examined showed no loss.

Results obtained in compression-molding of fine HMX/TNB compositions indicate that the ideal proportion of ingredients probably lies between the 95/5 and 94/6. It is believed that a 95.5/4.5 ratio should be investigated and pellets prepared without loss of TNB be characterized for mechanical and explosive properties.

It was found that an approximately 50/50 mix of coarse to fine HMX did not significantly change the pressing characteristics of the composition. It is therefore recommended that the use of various classes of HMX and RDX, both alone and in a mixture with fine material, be investigated to provide a basis for use of the most economical grades of these particulate explosives.

The use of PTFE was not adequately covered in this preliminary work. It is suggested, therefore, that this phase of the work be extended further using perhaps 94.5/4.5/1, 93/4.5/2.5, and 91.5/4.5/4 HMX/TNB/PTFE ratios to determine whether or not pellets of improved mechanical properties might be obtained through the use of PTFE without any essential loss of explosive effectiveness. Any improvements thus gained would be of great importance for uncased moldings which are to be machined or otherwise handled before placement into the end item.

A consideration of the compression-molding conditions and the results obtained indicates that the temperature of the heating oil is of far greater importance than is the air temperature within the heated mold, a parameter originally considered of prime importance. If higher densities are desired, it is recommended that pressing conditions be given further consideration to determine if preheating of the material to a temperature below the TNB melting point or increased dwell times during prepress heating and/or pressing would improve the density of the finished pellet.

REFERENCES

1. Chang Sun Choi and James E. Abel, *The Crystal Structure of 1,2,5-Trinitrobenzene by Neutron Diffraction,* Acta Crystallographica B28: 193-211 (1972)

2. Martin J. Buergner, *Crystal Structure Analysis,* Wiley & Sons, 1970

3. Private Communication, James E. Abel, 7 January 1974

4. *RDX,* Military Specification MIL-R-398C, Amendment 2 (MU), 28 April 1971

5. J. H. McIver, *Ballistic Pendulum Test,* Picatinny Arsenal Testing Manual 7-2, 8 May 1950

6. *Interim Amendment, Trinitrotoluene (TNT),* Military Specification MIL-T-248A, Amendment 3 (MU), 16 November 1968

7. *Explosive: Sampling, Inspection, and Testing,* Military Standard MIL-STD-650, 3 August 1962

8. Arthur J. Clear, *Standard Laboratory Procedures for Determining Sensitivity, Brisance and Stability of Explosives,* Picatinny Arsenal Technical Report PATR 3278, Rev 1, April 1970

9. *HMX,* Military Specification MIL-H45444A (ORD), Amendment 3, 31 July 1962

10. Robert S. Gow, *Explosive Compositions,* British Patent 1,089,403, 1 November 1967

DISTRIBUTION LIST

	Copy No.
Commander Picatinny Arsenal ATTN: Scientific and Technical Information Division	1-5
SARPA-AD-E, Mr. A. Roseff	6
SARPA-AD-D, Mr. C. Cavanaugh	7
SARPA-MT-C, Mr. S. Wachtel	8
Dover, New Jersey 07801	
Commander U. S. Army Armament Command ATTN: AMSAR-RE-RT	9
AMSAR-ASF	10
Rock Island, Illinois 61201	
Commander Frankford Arsenal ATTN: Pitman-Dunn Laboratories Bridge and Tacony Streets Philadelphia, Pennsylvania 19137	11
Commander Aberdeen Proving Ground ATTN: Technical Library Aberdeen, Maryland 21005	12-14
Redstone Scientific Information Center U. S. Army Missile Command ATTN: Chief, Document Station Redstone Arsenal, Alabama 35808	15
Commander Harry Diamond Laboratories ATTN: Library, Room 211, Bldg 92 Connecticut Avenue and Van Ness Street, NW Washington, D. C. 20438	16

Commander
U. S. Army Materiel Command
ATTN: AMCRD — 17
5001 Eisenhower Avenue
Alexandria, Virginia 22333

Dir Bureau of Mines
ATTN: Research Library — 18
4800 Forbes Avenue
Pittsburgh, Pennsylvania 15213

Lawrence Livermore Laboratory
University of California
ATTN: Research Library — 19
P.O. Box 808
Livermore, California 93555

Commander
Naval Weapons Center
ATTN: Technical Library — 20-22
China Lake, California 93555

Commander
U. S. Naval Surface Weapons Center
ATTN: Technical Library — 23
White Oak, Maryland 20910

Naval Ordnance Station
ATTN: Technical Library — 24
Indian Head, Maryland 20640

Commander
Eglin Air Force Base
ATTN: RTD Detachment No. 4 — 25
Florida 32542

Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314 — 26-37

NASA
Scientific and Technical Information Facility
P.O. Box 33
College Park, Maryland 20740 38

Commander
U. S. Naval Ammunition Depot
Code 5071
Crane, Indiana 47522 39